Synopsis for Registration as a Research Student

For Doctoral Degree

On

EEG Based Cognitive State Analysis and Classification

By

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Abstract

Cognitive State Classification (CBC) is a pivotal framework that enhances our understanding of human cognition, emotion, and behavior. This abstract provides a concise overview of the significance, methodologies, and applications of CBC. Cognitive state classification is an indispensable tool for exploring the depths of human cognition and emotion. Whether applied in clinical settings, research endeavors, or personal journeys of self-discovery, it empowers individuals and professional to unravel the intricacies of behavior, motivations, and that thought processes collected in the form of EEG (Electroencephalography)signal.

1. Introduction

Cognitive state classification is fundamental process in behavioral sciences thatinvolves the systematic classification and grouping of human thoughts, emotions, and actionsbased on underlying cognitive principles. This approach is integral to understanding, studying, and addressing various aspects of human behavior, mental health, and cognitive processes [10]. By categorizing behaviors within a structured framework, researchers, clinicians, and individuals can gain insights into the relationships between thoughts, emotions, and actions, ultimately leading to more effective interventions and improved well-being.

In this introductory exploration of cognitive state classification, we will delve into its significance, key components, and applications. We will also discuss the methodologies and tools used in this process, highlighting its relevance in fields ranging from psychology and therapy to education and self-improvement. Furthermore, we will examine how cognitive state classification can enhance our understanding of cognitive-behavioral therapy (CBT) [9] and contribute to personal growth and development.

Throughout this exploration, we will emphasize the importance of a structural and systematic approach to categorizing cognitive behavior, as it forms the foundation for evidence-based practices, effective interventions, and a deeper comprehension of the human mind and state[11]. That thoughts process changes after mindfulness (meditation) practice results varying user thought process positively changes. Concentration of user increases after meditation process thoughts process of thinking level updated in that process.Thought process of subject collected by using EEG (Electroencephalography) device. EEG-based measures of brain function [7] using different EEG, like Scalp EEG, Source EEG.

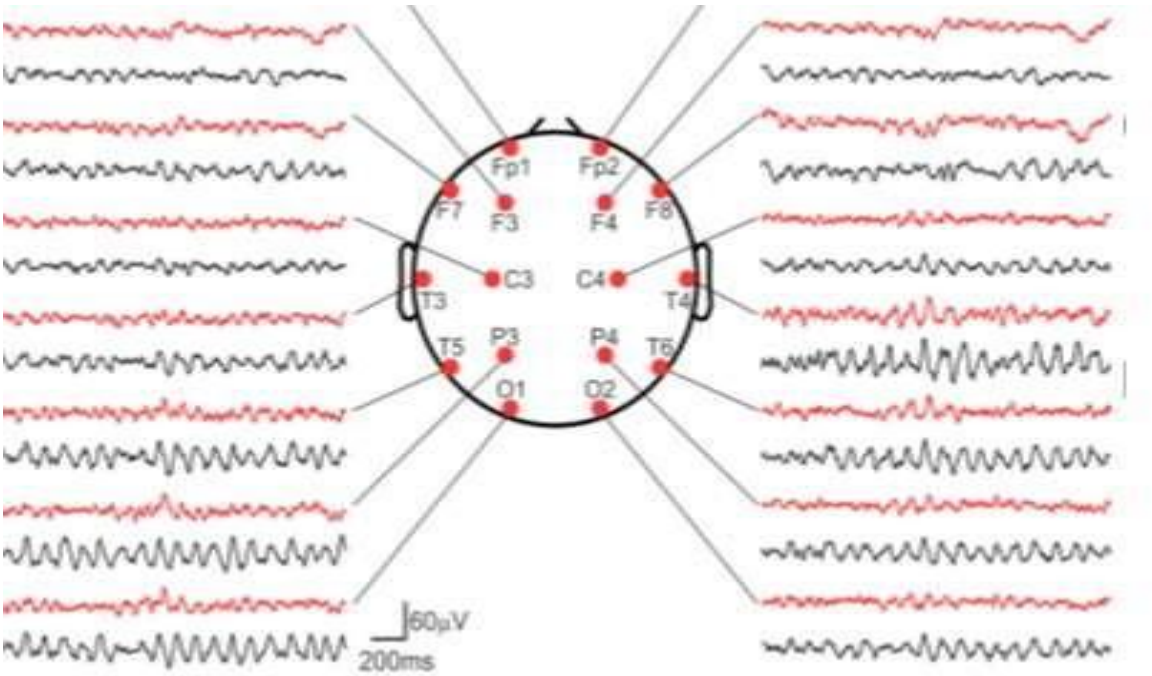

Fig. 1. Fundamental data collection and analysis. Example EEG traces from 16 scalp electrodes while a subject was sitting still with eyes closed (BASE, black) or performing the Hopkins VerbalLearning Test (HVLT, red).

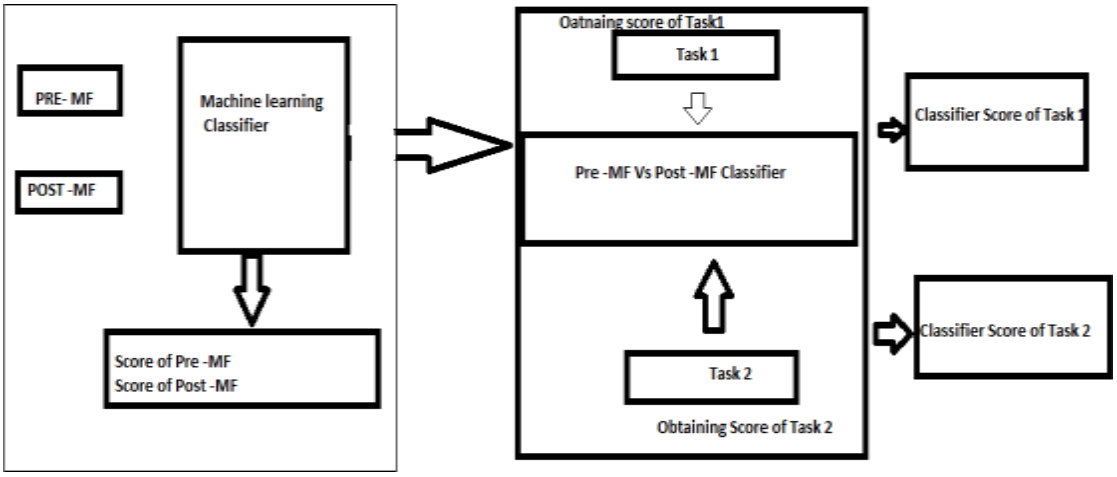

Fig 2 .Work flow for Cognitive state Classification

Cognitive state classification done by using FBCSP method and LSTM based deep group model [5]. FBCSP (Filter Bank Common Spatial Pattern) method consists of four stages, creation of filter

bank , extraction of special features from each filter bank. LSTM (Long Short Term Memory) network is a recurrent neural network (RNN), aimed to deal with the vanishing gradient problem present in traditional RNNs. Its relative insensitivity to gap length is its advantage over other RNNs, hidden Markov models and other sequence learning methods.

To check mindfulness meditation exercise in Autism Spectrum Disorder (ASD) using Electroencephalography (EEG) signal machine learning classifier develop.

2. Literature Survey

1. (Zhihan Lv, 2020) [9] Author used to check the cognitive computing of human state classification by using machine learning in their paper " Reducing depression and anxiety symptoms in patients with Parkinson's disease: The effectiveness of group cognitive behavioral therapy". DPCK-K-means clustering algorithm which can ensure the accuracy and stability of state classification.Along with this multi-modal approaches provide even better results.

2. (Dino Dvorak, APRIL 2018)[3] Author used to cognitive enhancement training to increase the number of electrode in their paper- "Cognitive Behavior Classification From Scalp EEG Signals " Here author use three common types of neural synchrony measures i.e. Power analysis, phase locking, and phase- amplitude coupling.

3. (Laxmi Shaw, DECEMBER 15, 2018) [5]" A New Framework to Infer Intra- and Inter-Brain Sparse Connectivity Estimation for EEG Source Information Flow".

4. (XUEGANG SONG, 2020) [8] Author used a method based on a combined high-order network and graph convolutional network in their paper "Classification of Mild Cognitive Impairment Based on a Combined High-Order Network and Graph Convolutional Network ". GCN is proposed to detect early stages of Alzheimer's disease by cognitive behavior.

5. (Busra T. Susam, 2022) [2] Author used to check mindfulness meditation exercise in Autism Spectrum Disorder (ASD) using Electroencephalography (EEG) in their paper "Quantitative EEG Changes in Youth With ASD Following BriefMindfulness Meditation Exercise ". Author develop machine learning classifier.

6. (McLoughlin, 2013) [7] "In search of biomarkers in psychiatry: EEG-based measures of brain function ". In this paper author compare brain function of human using different EEG, like Scalp EEG, Source EEG.

7. (Julia Basso, 2015) [4] Author perform the acute exercise test to improve prefrontal cortex function in healthy adult in their paper “Acute Exercise Improves Prefrontal Cortex but not Hippocampal Function in Healthy Adults “. In this paper it takes total 8 test Score of each test concluded to prefrontal cortex function of brain.

8. (Makmee, 2022) [6] “Increasing Attention and Working Memory in Elementary Students Using Mindfulness Training Programs”. In this paper author creates the 3 group two for experimental groups he gives short term mindfulness training to them the results of accuracy in working memory were high for trained groups but reaction time were same for all groups.

9. (Shrivatsa , 2022) [1] “Analysis of EEG Signals Using Open BCI to Predict the Stress Level”. In this paper author predict the stress level of human using brain computer Interface (BCI) after analysis of the EEG signals.

10. (Debashis Das , 2022)“EEG-Based Cognitive State Classification and Analysis of Brain Dynamics using Deep Ensemble Model and Graphical Brain Network” In this paper author predict the Cognitive state classification done by using FBCSP method and LSTM based deep group model [5]. FBCSP (Filter Bank Common Spatial Pattern) method consists of four stages, creation of filter bank , extraction of special features from each filter bank. LSTM (Long Short Term Memory) network is a recurrent neural network (RNN), aimed to deal with the vanishing gradient problem present in traditional RNNs. Its relative insensitivity to gap length is its advantage over other RNNs, hidden Markov models and other sequence learning methods.

11. (Jian Shen , 2023) “Exploring the Intrinsic Features of EEG Signals Via Empirical Mode Decomposition Recognition “ In this paper author uses regularization parameter based improved intrinsic feature extraction method of EEG signals via EMD(empirical mode decomposition) which mines the intrinsic patterns in EEG signals for depression recognition performance.

3. Challenges

1) **Measurement Issues:** Obtaining accurate and reliable data for classification can be challenging. Self-report measures, observation, and other data collection methods may introduce biases or inaccuracies.

2) **Overlap and Ambiguity:** Some behaviors may not neatly fit into one category and may exhibit overlap or ambiguity. For example, behaviors related to certain mental health disorders may have features of multiple categories.

3) **Ethical Considerations:** Classification can have ethical implications, particularly in sensitive areas such as mental health diagnosis or labeling. Ethical considerations related to privacy, stigma, and consent need to be addressed.

4) **Diagnostic challenges:** In clinical psychology, categorizing behaviors for diagnostic purposes can be challenging due to the heterogeneity of mental health conditions and the need for precise criteria.

4. Problem Definition

This research is aimed towards development of novel Cognitive state classification.In our research work the following problem(s) can be addressed:

- Design a Model to distinguish state of youth pre and post meditation.
- Recognizing importance of meditation in Autistic Spectrum Disorder Individuals from Normal individuals.
- Development of novel technique to classification of cognitive behavior.
- Performing Accuracy Evaluation of proposed model.

5. Future Research Plan

Year wise plan of work & targets	
Years	**Work plan**
First Year	Literature review, coursework, determining the advantages and disadvantages of the cognitive state classification, defining the problem, establishing objectives, and performing a feasibility study.
Second Year	Basic implementation, Development of Detection model and formulate results.
Third Year	Paper writing and publishing , Thesis writing .

6. Conclusion

Cognitive state classification is a multifaceted and indispensable process that provides extremely useful insights into the intricate world of human cognition, emotion, and action. This approach serves as a foundational framework in fields ranging from psychology and therapy to education and personal development. Through the systematic classification of behaviors based oncognitive principles, we gain a deeper understanding of how thoughts, emotions, and actions interplay to shape our lives. Addressing the challenges and issues in cognitive state classification is crucial for advancing our understanding of human behavior, improving mental health interventions, and enhancing personal and professional development. By tackling these problems through a multidisciplinary approach, we can refine our classification processes and contribute to the growth of this essential field.

7. References:

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5) Debashis Das Chakladar , Pratha Pratim Roy , Masakazu Iwamura "**EEG-Based Cognitive State Classification and Analysis of Brain Dynamics using Deep Ensemble Model and Graphical Brain Network**", IEE Transactions On Cognitive And Developmental , Systems Vol 14. No 4 December 2022

6) Pattrawadee Makmee **,** "**Increasing Attention and Working Memory in Elementary Students Using Mindfulness Training Programs",** FWU Journal of Social Sciences, Fall 2022, Vol.16, No.3, 107-119.

7) McLoughlin, G, Makeig, S. & Tsuang, MT, "**In search of biomarkers in psychiatry: EEG-based measures of brain function",** Journal of Medical Genetics: Neuropsychiatric Genetics, in press, 09/2013.

8) Xuegang Song, Ahmed Elazab, And Yuexin Zhang "**Classification of Mild Cognitive Impairment Based on a Combined High-Order Network and Graph Convolutional Network",** Digital Object Identifier 10.1109/ACCESS.2020.2974997, March 12, 2020.

9) Seyedeh Arefeh Rezazadeh Yazd , Sahar Gashtil , Mahboobeh Moradpoor , Sedigheh Pishdar , Pantea Nabian , Zahra Kazemi , Mahdi Naeim ," **Reducing depression and anxiety symptoms in patients with Parkinson's disease: The effectiveness of group cognitive behavioral therapy" ,** Science direct research article , Parkinsonism & Related Disorders22 May 2023.

10) Zachary D. Cohen, Nora M. Barnes-Horowitz, Courtney N. Forbes, Michelle G. Craske, **"Measuring the active elements of cognitive-behavioral therapies",** Science direct research article 2023.

11) Elizabeth A. Hoge , Naomi M. Simon , Kristin Szuhany , Benjamin Feldman , David Rosenfield , Susanne Hoeppner , Emma Jennings , Sat Bir Khalsa , Stefan G. Hofmann , **"Comparing Kundalini Yoga, cognitive behavioral therapy, and stress education for generalized anxiety disorder: Anxiety and depression symptom outcomes",** Science direct research article September 2023.

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